LA-UR-83-2399

CONF-830874--21

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36

TITLE: HIGH-SPEED VIDEOGRAPHY COMBINED WITH AN X-RAY IMAGE INTENSIFIER FOR DYNAMIC RADIOGRAPHY

LA-UR--83-2399

DE83 017233

AUTHOR(S) Lawrence E. b r.

SUBMITTED TO 1st National Conference on High-Speed Photography, Videography and Photonics, SPIE, San Diego, CA, August 21-26, 1983.

## DISCLAIMER



Los Alamos Los Alamos National Laboratory Los Alamos, New Mexico 87545

FORM NO 836 R4

MASTER

427-48

# High-Speed Videography Combined with an X-Ray Image Intensifier for Dynamic Radiography*

Lawrence E. Bryant, Jr.

Nondestructive Testing Unit, Los Alamos National Laboratory
Mail Stop C914, P. O. Box 1663, Los Alamos, New Mexico 87545

## Abstract

The Spin Physics SP-2000 high-speed video system can be combined with an x-ray source, a dynamic event having internal (not directly visible) movement and an x-ray image intensifier to perform dynamic radiography.

The cesium iodide input fluor and P-20 output fluor of the image intensifier have rapid decay to allow x-ray imaging up to 12,000 pictures per second.

Applications of this technique include internal functioning of a compressor, turbulent-water action, and other mechanical actions.

## Introduction

High-speed videography is an excellent technique for analyzing high-speed events, which can be optically imaged. Sometimes, however, the dynamic event is internal or partially internal such that it cannot be thoroughly diagnosed with a direct, optical approach.

X-ray, or using the more general term, radiography, has been used for years to image internal conditions, both statically and dynamically. This approach was initially termed "fluoroscopy" and is today generally termed "real time radiography." The technique uses a fluor, i.e., $CaWO_4$ or $Gd_2O_2S$, to convert a temporally and spatially varying x-ray beam to a visible image.

The next step can be direct observation, image intensification, video camera viewing or film camera viewing or certain combinations of these. The technique is used medically, in airport inspections, industrially, and scientifically. It normally views slow moving events or static objects which are being translated, rotated, etc. Where a video camera is involved, it is frequently a vidicon or perhaps a newvicon, plumbicon or other type. The video signal may be recorded and if played back, it is at the same frames per second rate with perhaps some "pause" viewing with little or no intention to "slow down" the internal action.

## Previous high-speed radiographic techniques

Radiography of high-speed events has also been performed. One prominent technique is "flash x-ray" where short duration x-ray pulses, i.e., 30 ns, are used to expose fast film/screen combinations to give a stop motion image. A number of these individual setups may be made for multiple images, either sequential or different perspectives, or both, but the amount of equipment required becomes impractical for more than several frames.

High-speed film cameras also can be employed to observe a fluor or the output of an image intensifier for x-ray imaging. Because of technique development delays in finding the proper exposure, delays in film processing and the small format of the film images, this approach is not in frequent use.

## High-speed videography combined with dynamic radiography

In an effort to overcome the problems elaborated in the above section, Los Alamos has combined our recently acquired Spin Physics Motion Analysis System with x-ray sources, dynamic internal events and a x-ray image intensifier to perform high-speed real time radiography. The setup is shown schematically in Figure 1.

Depending on the application, x-ray generators of different characteristics can be employed to achieve a desired balance between sufficient penetration by the x-rays and adequate differential absorption of radiation to give suitable contrast. Some x-ray generators and radioactive isotopes for radiography are portable, allowing field high-speed radiography. Otherwise the experiment would have to be brought to the location of a fixed installation x-ray generator.

The axis of radiation is normally centered on the input circle of the image intensifier. The event or object with dynamic internal action is positioned between the radiation source and image intensifier, normally closest to the latter with the region of interest centered on the image intensifier. There are a number of types of x-ray image intensifiers (typical one is schematically shown in Figure 2). The one used in these experiments is a Precise Optics, 9-inch diameter input model. The input fluor is cesium iodide, which has a decay constant of 650 ns and the output fluor is a P20 type with a decay constant of 85 ns. These are sufficiently fast decays for imaging up to 12,000 pictures per second with no noticeable lag. It is not necessary to gate the x-ray source or the image intensifier. The cesium iodide fluor in this particular intensifier is useful for imaging -rays from approximately 50 kilovolts to 5 MeV, a wide range of energies applicable to a variety of objects or events.

The Spin Physics camera is mounted at the output fluor port of the x-ray image intensifier. The standard zoom lens was replaced with a Canon 50 mm Video Lens set at f/.95 and focused at infinity. This lens used more efficiently the available light from the fluor. The camera is shielded with an appropriate thickness of lead from any direct radiation. The object or dynamic event may be masked with lead to prevent excess radiation from striking the input fluor and degrading the radiographic image. The control console for the Spin Physics System is located in a radiation safe area near the x-ray generator controls. The console is connected to the high-speed camera by one or more extension cables as necessary.

## Applications

Thus far our applications have been either demonstrations or those not suitable to show a general audience. Therefore, several of the demonstrations will serve to illustrate this technique. It should be noted that the best way to view the results is to watch the video tape playback. This approach will be used for 2.5 MeV dynamic radiography of a two-cylinder compressor with recording at 500 fps and visualization of pistons, a connecting rod and the crank shaft. This is also the only meaningful way to visualize the 150 pkv radiography of a room fan running at several speeds with and without oscillation. The main feature in a series of recordings up to 2000 fps, is the action of the worm gear.

For purposes of this paper and presentation of still images, radiography at high-speed of a clock and turbulent water in an aluminum pipe are presented.

Figure 3 shows two radiographic images of the clock recorded at 200 fps. The most notable feature is the balance wheel in the center-right region of the picture which has rotated about 90° in 0.035 second.

Figure 4 shows the setup for the turbulent water demonstration. The 150 pKv x-ray generator (a) is shown at the left. The 3-inch dia., 1/8 inch wall thickness aluminum cylinder is shown next (b). To the right is the image intensifier (c) and high-speed video camera (d) mounted at the output fluor access.

Figure 5 shows two images of turbulent water at a time interval of 0.008 second. The first image shows a rather turbulent water/air interface whereas in the second image, this region is relatively calm. Bubbles moving up through the water column are much more easily visualized on the video tape presentation.

## Conclusions

High-speed radiography using the Spin Physics Camera to record the output fluor images appears to be a useful technique. One could use a two camera system for two different x-ray views or for one x-ray view and one optical view as seen in Figure 6 for a fan with different lead markers attached to successive blades as recorded at 4000 fps. A successful application depends on the availability of a suitable radiation source and observance of good radiographic practice as to setup geometry and masking of scattered radiation

It is hoped that at the next meeting of this group there will be reports of truly useful applications of this technique.

*Work performed under the auspices of the U. S. Department of Energy, Contract No. W7405-ENG-36.

42 48

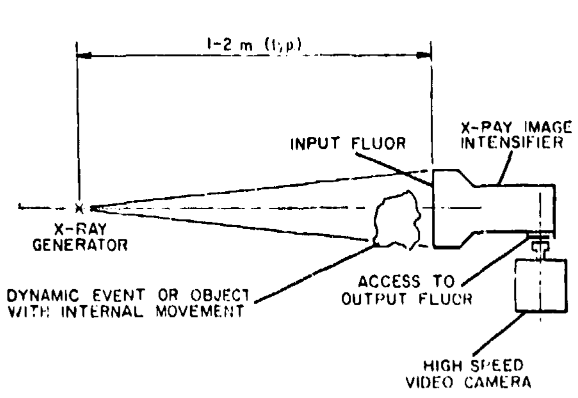


Figure 1. Schematic of High Speed Video Combined with Dynamic Radiography.

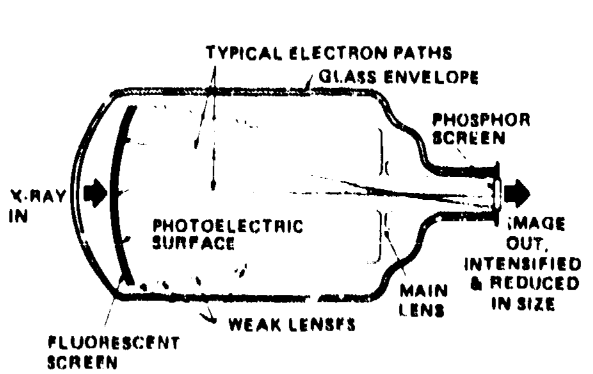


Figure 2. Schematic of X-Ray Image Intensifier.

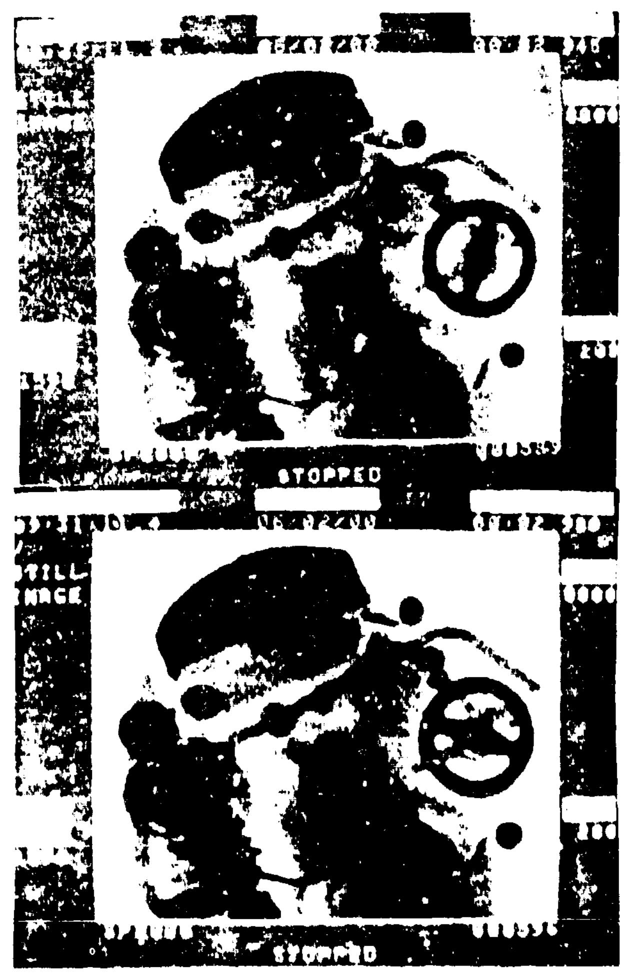


Figure 3. High-Speed Video/X-Ray Image of Clock.

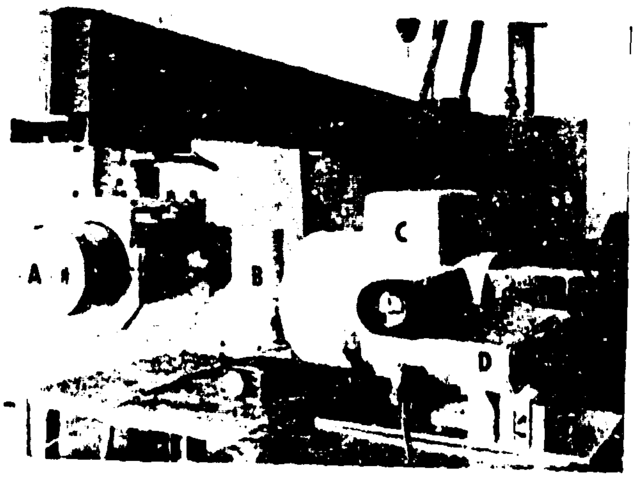


Figure 4 Setup for Dynamic Radiography; X-Ray Generator (A), Object (B), Image Intensifier (C), High-Speed Video Camera (D).

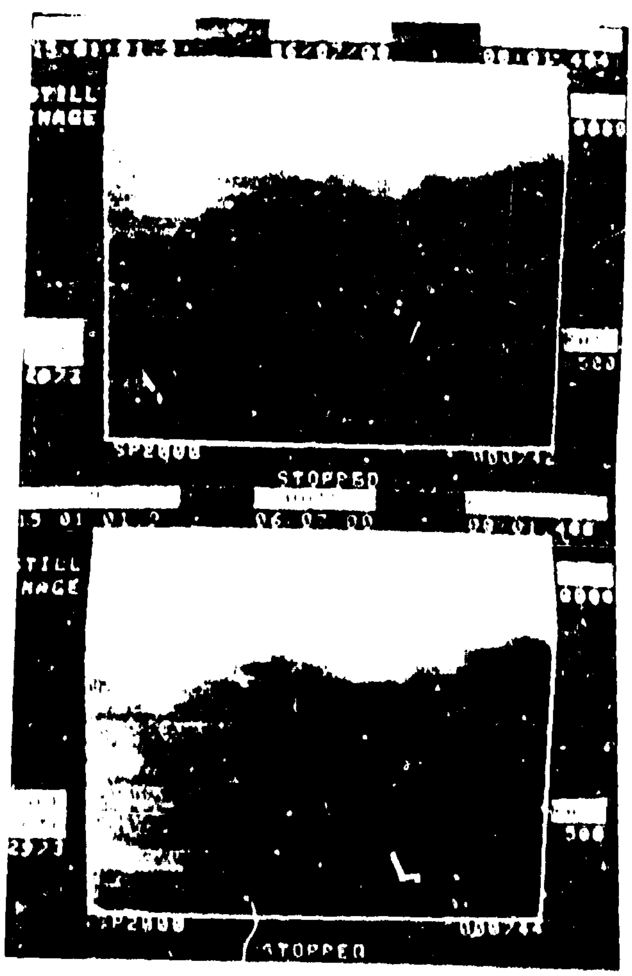


Figure 5. High-Speed Video/X-Ray Images of Turbulent Water.


Figure 6. High-Speed Video Optical and X-Ray Images of Rotating Fan.